PALAEONTOLOGY OF THE BAGH BEDS

II. Echinoidea

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Abstract

Study of recent collection of echinoids from the Bagh Beds has yielded four new species. Distribution of the echinoid species in these strata does not warrant treating each constituent member of the series as a distinct unit having its own characteristic species or an assemblage of species; and in spite of their lithological differences, they together constitute a single palaeontological unit. Affinities of these echinoids range from Aptian to Senonian; but their mixture in all the strata, lower as well as upper, shows that Cenomanian is the most conspicuous element throughout. Also, the two genera *Polydiadema* and *Tetragramma* not known to survive the Cenomanian times set this as the upper age limit, and six out of eight species of *Hemiaster* belong to the subgenus *Mecaster* appearing in Cenomanian, and thus set the lower age limit for the 'Bagh echinoid fauna'. Thus this echinoid fauna has to be taken as of Cenomanian age. Further, their faunal affinities are undoubtedly with the Mediterranean Palaeo-zoo-geographic province, particularly the North African region.

Co-ordinates of the Localities Cited in the Text

Badia	22″19′30″:75°01′
Bagh	22°21′30″:74°47′
Bowarla	22°18′30″:75°11′
Chirakhan	22°22′30″:75°07′
Deola	22°19′ :75°06′
Mongra	22°00′30″:74°20′30″
Moti Chikli	22°21′ :74°19′10″
Rampura	22°17′30″:74°46′52″
Sitapuri	22°20 : 75°5′ 30″
Walpur	22°07′30″:74°29′
Zirabad	22°24′30″:75°04′30″

INTRODUCTION

AMONG the Bagh fossils echinoids were the first to receive detailed attention at the hands of Duncan who placed them at the Upper Greensand horizon (1865, 1887). Fourtau (1918) revised the group and thought that they were more aptly given the Upper Albian Age. Chiplonkar (1937, 1939) with more material at his disposal found that Cenomanian would be the appropriate age for the Bagh echinoid fauna. All these workers also found them unmistakably allied to the Mediterranean palaeo-zoo-geographic province and considered the Bagh Beds to be a single palaeontological unit, contrary to Bose's view (1884) correlating them as a series of beds on par with the stages of the South Indian Cretaceous series.

The nomenclature and the sequence of the taxa followed here is in accordance with Part 'U' of the *Treatise on Invertebrate Palaeontology* edited by R. C. Moore.

HOLOTYPES AND NEOTYPES

The Bagh fossils studied by Chiplonkar (1937-43) which were deposited at the Department of Geology, Banaras Hindu University, are lost. So the *Holotypes* of the species described by him are being replaced by *Neotypes* as indicated here and described only briefly. It is a fortunate coincidence that Chiplonkar is associated with the present work on Bagh fossils. All the *Holotypes* and *Neotypes* of the species described here are preserved at the Maharashtra Association for the Cultivation of Science, Poona-4.

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General Remarks

Table 1 summarises the distribution of Bagh echinoids within the series and their affinities towards species from other regions. To go briefly over the main points of relation of these species we find that the commonest of the echinoids *Hemiaster fourtaui* Chipl. has its nearest ally, *H. luynesi* Cotteau in the Cenomanian of Palestine. *H. rarus* sp. nov. has its nearest species *H. batnesis* Coq. from Cenomanian (Mornesian) of Algeria. *H. heberti* Coq., *H. saadense* Peron and Gauthier and *H. meslei* Peron and Gauthier are known from Cenomanian rocks of Egypt, Tunisia and Algeria. *Nucleolites chirakhanensis* (Chipl.) has its nearest relation, *N. similis* Desor from the Cenomanian of Sarthe. Of the regular echinoids in these beds we have two genera, *Diplopodia* (*Tetragramma*) and *Polydiadema*, which are not known to survive the Cenomanian period and which thus set the upper age limit for the Bagh echinoids. It may further be added that of the eight species of *Hemiaster* reported from these beds six belong to the subgenus *Mecaster* which appears in Cenomanian, and thus sets the lower age limit. Most of the species of *Nucleolites* have their affinities to Albian and Aptian species. Regular echinoids have their allies from Valanginian, Aptian and Albian horizons in European and North African countries. The remaining species are related to those from Cenomanian to Senonian horizons in Africa and Persia. Thus the affinities of these Bagh echinoids range from Aptian to Senonian.

If these affinities were found to range essentially in a regular manner from Albian to Senonian as we traced the distribution of these species from below upwards, bed by bed, then we would have been forced to assign to these strata long period extending from Aptian to Senonian. But we find that species with Albian and Aptian affinities are associated in these rocks, lower as also upper, with those having Senonian affinities and also with those having Cenomanian affinities. Thus we have here a mixture of affinities in every sense of the word, Cenomanian being the most conspicuous aspect of it. Hence, we consider it appropriate to place the Bagh echinoids at the Cenomanian horizon, thus falling essentially in agreement with the views of earlier workers on this group of the Bagh fauna (Duncan, 1865, p. 349; 1887, p. 87; Chiplonkar, 1937, p. 67; 1939, p. 244; Fourtau, 1918, p. 55).

TABLE I

Showing the vertical distribution and affinity relations of the echinoids from the Bagh Beds

No.	Species from the Bagh Beds	Related species with stratigraphical position	Nodular Limestone	Lower Coralline Limestone	Deola-Chirakhan Marl	Upper Coralline Limestone
1	*Cidaris namadicus* (Duncan) ..	*C. jullieni* (Gauthier), Aptian of Algeria	..	..	X	X
2	*Salenia keatingei* Fourtau ..	*S. mamillata* Cotteau, Aptian of France	..	..	X	..
3	*S. mathuri* Chiplonkar ..	*S. cylindrica* Arnaud, Aptian-Albian of France	..	..	X	..
4	*Polydiadema bosei* sp. nov. ..	*P. lamberti* Thiery, Valanginian of Ardesche, Beaulien	X	..	..	..
5	*Tetragrama mieropyga* (Fourtau)*	*T. micropyga* (Fourtou), Lower Cenomanian of Egypt	..	..	X	..
6	*Phymosoma mongraensis* sp. nov.	*P. mai r* (Coq.), Cenomanian of Constentine and *P. mobile* (Cotteau) from Valanginian of Switzerland	X	..	..	..
7	*P. nemadicum* (Fourtau) ..	*P. peroni* (Cotteau), Barremian-Aptian of France and Switzerland	..	..	X	..
8	*Orthopsis indica* Duncan* ..	*O. repellini* Desor, Barremian-Aptian of France and Switzerland	..	..	X	..
9	*Nucleolites elongatus* sp. nov. ..	*N. hori* (Fortau), Aptian of Egypt	..	..	X	..
10	*N. haydeni* (Fourtau)* ..	*N. eddissensis* (Gauthier), Aptian-Albian of Algeria and Tunis	X	X	X	X
11	*K. malwaensis* Chiplonkar ..	*N. nicoleti* (d'Orb.), Urgonian of France	..	..	X	..
12	*N. chirakhanensis* Chiplonkar ..	*N. similis* Desor, Cenomanian of Sarthe	..	?	X	X
13	*N. rajnathi* Chiplonkar ..	*N. koechlini* (d'Orb), Albian of France	?	..	X	?
14	*Hemiaster holoambitatus* Chiplonkar	*H. soullerie* Fallot, Senonian of France	X	X	X	X
15	*H. subsimilis* Fourtau ..	*H. morgani* Cotteau and Gauthier, Senonian of Persia	X	X	X	X
16	*H. (Mecaster) rarus* sp. nov. ..	*H. (mecaster) batnensis* (Coq.), Mornasian of Constantine	..	..	X	.. X
17	*H. (Mecaster) fourtaui* Chiplonkar	*H. luynesi* Cotteau, Cenomanian of Palestine	X	X	X	
18	*H. (Mecaster) chirakhanensis* Chiplonkar	*H. (mecaster) Thomasi* Peron and Gauthier, Senonian of Algeria	..	X	X	X
19	*H. (Mecaster) meslei* Peron and Gauthier	*H. (macaster) meslei* Peron and Gauthier, Cenomanian of Algeria, Tunis and Egypt	..	X	X	X
20	*H. (Mecaster) heberti* (Coq.) ..	*H. (mecaster) heberti* (Coq.), Cenomanian of Algeria and Egypt	..	..	X	..
21	*H. (Mecaster) saadensis* Peron and Gauthier*	*H. (mecaster) saadensis* Peron and Gauthier, Cenomanian of Algeria	..	..	X	X

* These species are not present in our collection, but were reported by Chiplonkar, Fourtau and Duncan.

* Subsequent to discussing the age and affinities of the Bagh fauna in 1942, I had a few occasions to re-examine my old Bagh collection of fossils deposited at the Geology Department, Banaras Hindu University, and I was convinced that what I had described then (1937, p. 62, Pl. VI, Fig. 1) as *Diplopodia* (*Tetragramma*) aff. *micropyga* Fourtau, was definitely assignable to that species of Fourtau; but at that time I deferred saying so till I got an occasion to report it along with some more echinoids from these rocks; now I have to say that *Tetragramma micropyga* Fourtau, a Cenomanian species from Egypt, was among that collection of Bagh echinoids, though it is not represented in the collection being reported upon here.—G. W. Chiplonkar.

The details about the occurrence of the species allied to these Bagh echinoids given in the table are expressive enough to show that they belong to the Mediterranean palaeo-zoo-geographic province particularly North African region and need no elaboration.

Regarding the distribution of echinoid species in these beds it is seen that almost all the species are present in the Deola-Chirakhan Marl; many of them are present in the two Coralline Limestones on either side of it, some also extending down into the Nodular Limestone. *Hemiaster fourtaui* Chipl. a species particularly abundant in these rocks occurs in all the beds of the series accompanied by *Nucleolites haydeni* (Fourtau), *Hemiaster subsimilis* (Fourtau) and *Hemiaster holoambitatus* Chipl., the last two species being again fairly abundant. It is thus clear that on the basis of distribution of the echinoid species all the constituent members of this series together make a single palaeontological unit assignable to a short period, *viz.*, the Cenomanian. The differences are of lithic facies and not of age nor of palaeontological succession. The echinoid fauna therefore does not permit correlation of these strata stage by stage, with the series of Cretaceous rocks of South India as was done by Bose (1884, pp. 36–44); Mukerjee (1958, p. 196); and Verma (1966, p. 241). This again is the conclusion arrived at also by earlier workers, *viz.*, Duncan (1887, p. 87), Kosamatt (1895, p. 42; 1897, p. 77), Fourtau (1918, p. 34) and Chiplonkar (1937, p. 67; 1939, p. 245).

Description of the Species

Order : *Cidaroida* Claus, 1880
Family : *Cidaridae* Gray, 1825
Genus : *Cidaris* Leske, 1778.

Cidaris namadicus Duncan

(Pl. XI; Figs. 1, 4 and 7)

1887 *Cidaris namadicus* Duncan: Duncan. p. 87. Figs. 1–3.
1918 *Dorocidaris namadicus* (Duncan). Fourtau, p. 35, Pl. I, Figs. 1, 2,

Material:—4 specimens, Ch. 40/69.

Dimensions:—

	Height of test	Diameter of test	Diameter of apical disc	Diameter of Peristome
	mm	mm	mm	mm
Ch 40/69 ..	42	53	24	20
Ch 41/69 ..	47	58	25	20
Ch 42/69 ..	32	44	20	16

Remarks—The specimens representing this species in our collection are better preserved than in collection of earlier workers, thus making it possible for us to give the various dimensions and also the photographs.

Occurrence.—Deola-Chirakhan Marl at Badia and Chirakhan.

Order: *Salenioida* Delage & Herouard, 1903.
Family: *Saleniidae* Agassiz, 1858.
Genus: *Salenia* Gray, 1835.

Salenia mathuri Chiplonkar
(Pl. XI, Figs. 14, 15 and 16)

1937 *Salenia mathuri* Chipl.: Chiplonkar, p. 61, Pl. VI, Figs. 3 *a–d.*

Material.—2 specimens. *Neotype* Si 128/69.

Dimensions:	Height of test	Diameter of test
	mm	mm
Si 128/69 ..	8	14
Si 129/69 ..	6	12

Remarks.—The salient features of this species are—a depressed test; small peristome with well-marked branchial incisions; genital plates as broad as high and ornamented with radial grooves; the ambulacral areas wide and flexuous; pore pairs obliquely situated, uniserial adapically, becoming gradually biserial from half way between ambitus and peristome; and the scrobicular rings of the "Quadrate" type of Arnaud. (Arnaud, 1897, p. 30).

Occurrence.—Deola-Chirakhan Marl at Sitapuri.

Order: *Hemicidaroida* Beurlen, 1937.

Family: *Pseudodiadematidae* Pomel, 1883.

Genus: *Polydiadema* Lambert, 1888.

Polydiadema bosei sp. nov.

(Pl. I, Figs. 8, 9 & 10

Material.—1 Specimen. *Holotype* Mor. 123/69.

Description.—A single fragmentary specimen represents this species in our collection. The test is wheel-shaped and sub-pentagonal in outline. The upper surface appears to be very slightly raised. The apical disc is not preserved, but with the impression that can be gathered from the presumed margin of space left by it, it has the appearance of being caducous.

The ambulacral areas are narrow and pairs of rounded ambulacral pores of each compound plate form an arched group. The pores are uniserial adapically and near the ambitus but show scattering adorally. Each compound plate is made up of five plates. The ambulacral columns consist of fourteen compound plates, each bearing a primary tubercle, perforate and crenulate, and surrounded by a depressed scrobicular ring encircled by a single series of miliary granules. The miliary granules at the corners of the plates are bigger than the rest.

Interambulacral areas are twice as wide as the ambulacral areas. The primary tubercles, crenalate and perforate, are of the same prominence as those on the ambulacral plates. A second row of smaller crenulate and perforate tubercles is adradial in position. These tubercles are situated at a slightly lower level than the main tubercle and thus alternate with them. Both the tubercles have depressed scrobicular rings surrounded by miliary granules which show crowding along interradial suture. Whether they disappear or only decrease in prominance towards the apical disc is uncertain due to weathered nature of the specimen. The peristome has well-developed branchial incisions.

Remarks.—As compared to *Polydiadema texanum* (Roemer) (Roemer, 1852, p. 83, Pl. X, Fig. 5; Smiser, 1933, p. 138, Pl. XVIII, Figs. 6–7), a form from the Fredericksburg group (lower Albian), present species differs greatly since the former has straight series of ambulacral plates, the primary tubercles from the interambulacral areas, distinctly larger than those from the ambulacral areas, no distinct depressed scrobicular areas around the primary tubercles, both from the ambulacral and interambulacral areas, and secondary tubercles not well developed.

Closer to our species is *Polydiadema lamberti* Thiery (Collingnon and Lambert, 1928, p. 226, Pl. XX, Figs. 5–7) from Valanginian of Ardesche, which, however, differs from our species by having only eight compound ambulacral plates in each column, incomplete scrobicular rings around the tubercles, less scattering of the pores on the oral side and a taller test.

Occurrence.—Nodular limestone at Mongra.

Order: *Phymosomatoida* Mortensen, 1904.

Family: *Phymosomatidae* Pomel, 1883.

Genus: *Phymosoma* Haine, 1853.

Phymosoma mongraensis sp. nov.
(Pl. XI, Figs. 5, 6)

Material.—9 specimens. *Holotype* Mor. 114/69.

Dimensions:

	Height of test mm	Diameter of test mm
Mor. 114/69	13	26
Mor. 115/69	21	32
Gun. 20	16	32

Description.—The test is low with flat apical surface. The apical system is not preserved but its space as seen on the specimens is distinctly pentagonal and is approximately one-half of the diameter of the test.

The ambulacral area is narrow and formed by fourteen compound plates. Each compound plate is of five plates. The pore pairs are uniserial at the apical region and the ambitus; but beyond the ambitus they are scattered towards the peristome where they tend to become biserial. The pores are circular and non-conjugate. Each compound plate carries a single primary crenulate and imperforate tubercle surrounded by a depressed scrobicular area. The miliary granules are situated in line with the pore pairs. The interambulacral area is nearly one and a half times wider than the ambulacral area.

Each interambulacral plate carries three primary crenulate, imperforate tubercles, the middle tubercle is the biggest in size, the one on the inner side being the smallest. The inner series of these tubercles tend to die out adapically after reaching nearly 2/3rds of the height. The biggest tubercle is slightly at a higher level than the other two. The size of the

biggest interambulacral tubercle is almost the same as that of the primary tubercle of the ambulacral area.

The peristome is approximately 1/3rd of the diameter of the test with distinct branchial incisions.

Remarks.—As compared to *Cyphosoma namadicum* Fourtau an associated form (*vide infra*) the present species is distinctly taller but less elevated apically, has a rather elongated pentagonal area of the apical disc and a larger number of ambulacral plates (14).

Distinctly lesser height of the test and larger apical disc distinguish *Phymosoma nobile* (Cotteau) from Valanginian of Switzerland (Loriol, 1868, p. 71, Pl. 7, Figs. 6, 7) from our species.

Phymosoma major Coq. (Coquand, 1862, p. 256, Pl. 27, Figs. 16-18) from Mornasion (Cenomanian) of Constantine has its dimensions, number of plates constituting the carona and arrangement of pore pairs like our species, but it differs in having smaller apical system and smaller peristome.

In dimensions and shape our species resembles *Phymosoma guelbense* Gauthier (Lambert, 1932, p. 71, Pl. 3, Figs. 15, 16) from the Turonian of Algeria, but differs by the secondary tubercles in its interambulacral areas, particularly at the ambitus, being almost as prominent as the primary tubercles and biserial arrangement of pore pairs both at oral and aboral region.

By its form, dimensions, flat, base larger area of apical disc and subflexuous nature of poriferous zones *Phymosoma thevetense* Peron and Gauthier (Peron and Gauthier, 1879, p. 105, Pl. 8, Figs. 5–8) from Turonian of Algeria resembles closely our species at first sight but can be easily separated by the former having only two rows of the primary non-crenulate tubercles in the interambulacral area and biserial arrangement of pore pairs towards apex.

Of the species compared here, the present species appears nearest to *P. nobele* (Cotteau) and *P. major* (Coq.).

Occurrence.—Nodular limestone at Mongra and Guneri, 4 miles East of Walpur.

Phymosoma namadicum (Fourtau)
(Pl. XI, Figs. 13 and 17)

1887 *Cyphosoma cenomanense* Duncan non-Cotteau, Duncan, p. 89.
1918 *Cyphosoma namadicum* Fourtau: Fourtau, p. 41, Pl. I, Fig. 4.
Material.—Large number of specimens. Si 126/69.

Remarks.—All our specimens are rather eroded, but one of them (Si 126/69) shows on a few of the primary tubercles in the ambulacral area, what looks like radial ornament extending from the suture of the compound plates and going up to the boss of the tubercles. This point is neither mentioned by Fourtau in his description of this species nor is visible on his type specimen. Otherwise, our material agrees well with Fourtau's, including tendency to a relatively taller test in larger specimens.

Occurrence: Deola Chirakhan Marl at Sitapuri.

Order: *Cassiduloida* Claus, 1880.

Family: *Nucleolitidae* L. Agassiz & Desor, 1847.

Genus: *Nucleolites* Lamarck, 1801.

Nucleolites elongatus sp. nov.
(Pl. XII, Figs. 17 and 22)

Material: One specimen. *Holotype* CH 401.

Dimensions:	Length	Breadth	Height	L/B	L/H
CH 401	22 mm	17·5 mm	9 mm	1·25	2·44

Description.—This is an elongate form, narrowing slightly in front. The general appearance of the test is rectangular. The apical disc is at 2/5ths of the length from the front. The point of maximum height is at 3/5ths of the length from the front. The upper surface slopes more to the anterior than to the posterior. The periproctal groove is narrow and extends upto 2/5ths of the length from the posterior side and does not produce any indentation at the ambitus.

The lanceolate ambulacrals have their interporiferous zones nearly twice as wide as the poriferous ones. Posterior ambulacrals are slightly longer than the anterior pair.

Orally, the test is much depressed and the peristome is situated at 1/3rd the length from the anterior.

Remarks.—Present species differs from *E. haydeni* Fourtau (Fourtau, 1918, p. 44, Pl. 2, Fig. 1) in having a test less tall and more elongated with no posterior indentation produced by the periproctal groove and a more depressed oral surface; also the anterior rounding begins much earlier giving a narrow appearance to the test in this region.

It differs from the associated *N. rajnathi* (Chipl.), *N. chirakhanensis* (Chipl.) and *N. malwaensis* (Chipl.) by its obviously elongate and rectangular shape.

As compared to *Nucleolites julieni* (Coq.) from lower Campanian of Constantine (Coquand, 1862, p. 252, Pl. 28, Figs. 5–7) our form agrees in length and breadth but the Algerian form is distinctly less tall and its posterior ambulacrals are more divergent.

Nucleolites hori (Fortau) (Fourtau, 1921, p. 66, Pl. 9, Figs. 3–4) from Aptian of Egypt is very similar in outline but is a distinctly taller species with summit coming approximately at 1/3rd of the length from the front. Otherwise, this species is nearest to the present one.

Occurrence.—Deola-Chirakhan Marl at Chirakhan.

Nucleolites rajnathi (Chiplonkar)
(Pl. XI, Figs. 11 and 12, Pl. XII, Fig. 18)

1939 *Echinobrissus rajnathi* Chipl.: Chiplonkar, p. 238, Pl. 25, Fig. 2.

Material.—Large Number of specimens. *Neotype* Si 311/69.

Remarks.—Briefly, the test is longer than broad, sub-centrally highest, ambitally tumid, upper surface slightly steeper behind than in front with apical disc at 2/5ths of the length from front, narrow periproctal groove, producing a feeble indent at posterior margin. Thus the present material agrees fully with the description and figures given by Chiplonkar.

Occurrence.—Deola-Chirakhan Marl and Upper Coralline Limestone at Sitapuri and Chirakhan.

Nucleolites chirakhanensis (Chiplonkar)
(Pl. XI, Figs. 2 and 3, Pl. XII, Figs, 16 and 21)

1939 *Echinobrissus chirakhanensis* Chipl., Chiplonkar, p. 237, Pl. 25, Fig. 3.

Material.—3 specimens. *Neotype* Ch 403.

Remarks.—By squarish outline, apical disc coming at the summit, slight indentation at the posterior margin at ambitus and slightly longer posterior paired ambulacral petals, our present specimens agree fully with *N. chirakhanensis* (Chipl.).

Occurrence.—Deola-Chirakhan Marl at Chirakhan and Sitapuri.

Nucleolites malwaensis (Chiplonkar)
(Pl. XII, Figs. 20 and 12)

1939 *Echinobrissus malwaensis* Chipl.: Chiplonkar, p. 236, Pl. 25, Fig. 1.

Material.—3 specimens. *Neotype* Ch 402.

Remarks.—By sub-rectangular outline, with parallel sides and the summit and apical disc coming at about 2/5ths of the length from the anterior side present material agrees with *N. malwaensis* (Chipl.).

Occurrence.—Deola-Chiramhan Marl at Chirakhan and Sitapuri.

Order: *Spatangoida* Claus, 1876.
Sub-order: *Hemiasterina* Fischer, 1966.
Family: *Hemiasteridae* Clarke, 1917.
Genus: *Hemiaster* Agassiz, 1847.

Hemiaster holoambitatus Chiplonkar
(Pl. XII, Figs. 9 and 13)

1887 *Hemiaster similis* (Pars.) Duncan, non d'Orbigny nec Cotteau, nec Oldham: Duncan, p. 92.

1918 *Opisaster sp. indet.*: Fourtau, p. 51, Pl. 2, Fig. 4.

1937 *Hemiaster holoambitatus* Chipl.: Chiplonkar, p. 64, Pl. 6, Fig. 4.

Material.—Large number of specimens. *Neotype* Ch 65.

Remarks.—All the specimens, juvenile as well as adult, representing this species have the grooves carrying the ambulacral areas very shallow; the frontal sinus is totally absent or just doubtfully present; also the fasciole passes just at the tips of the paired ambulacral petals and crosses the odd ambulacre above the ambitus so as to follow a smooth and regular course. In this respect the present species shows the characters of *Bolbaster* Pomel (Moore, 1966, p. 558, Fig. 442·2) and *Holanthus* Lambert and Thiery (Moore, 1966, p. 559), both of which, however, have their posterior petals long. By its posterior petals markedly shorter than the anterior petals this species has the appearance of *Leymeriaster* (Moore, 1966, p 559, Fig. 443·2), which, however, has its anterior sulcus broad and shallow, producing a frontal sinus distinct though shallow, and has its fasciole going closely along the margins of the paired petals and crossing the odd ambulacre just next to the apical disc, and thus having a deeply indented four-petalled pattern. The present species, therefore, does not fit into any of these subgeneric groups, and a new subgenus may be needed to receive it along with *H. soullerie* Fallot and other species with which it is compared further below.

Chiplonkar (1937, p. 65) had remarked that this species combines the characters of *Hemiaster sensu stricto* and *Integraster* of Lambert and Thiery; but the latter genus is now regarded as a synonym of the former (Moore, 1966, p. 558). This species, along with the next one, was placed by Fourtau

(1918, p. 50) under the genus *Opisaster* Fomel, but was removed from there by Chiplonkar (1937, p. 60) for reasons given here, under the next species.

Test oval with almost vertical posterior face; rounded front and apical disc at 1/3rd length from behind, and the groove carrying the odd ambulacre not producing any indent in the front give it a characteristic appearance to separate it easily from all the associated species of *Hemiaster*.

To compare the present species with others, *viz.*, *H. madagascarensis* Cottreau (Cottreau, 1922, p. 118, Pl. 2, Figs. 1–8; Lambert 1903, p. 87, Pl. 3, Figs. 6–8; Boule and Thevenin, 1906, p. 53, Pl. 2, Fig. 6) from upper Senonian of Madagascar, *H. integer* Lambert (Lambert, 1933, p. 21, Pl. 3, Figs. 5–6) from Turonian of Madagascar, *H. auberti* (Gauthier, 1889, Pl. 1, Figs. 17–18) from Tunis and *H. mirabilis* Peron and Gauthier (Cotteau, Peron and Gauthier, 1879, p. 145, Pl. 14, Figs. 1–5) from Dordonian of Algeria, all of which have a similarly entire ambitus, leaving aside details of differences in other respects shown by each of them, one common feature which separates them all as a group from *H. holoambitatus* Chipl. is that the Bagh species has its apical disc more posteriorly situated. But *H. soullerie* Fallot (Fallot 1885, p. 258, Pl. 8, Figs. 2–3) from Senonian of France agrees with our species on this point though this French species can be distinguished by its test having its maximum width spread over a wider region giving to its test on the whole a very broadly elliptical outline and having its grooves carrying the ambulacral areas a little deeper.

In the light of comparisons made here, *H. holoambitatus* is probably even nearer to *H. soullerie* Fallot than to *H. rutoti* Lambert and *H. astarias* Forbes as regarded by Chiplonkar (Chiplonkar, 1937, p. 65).

Occurrence.—Nodular Limestone at Mongra, Khadlu, Walpur, Rampura and Bagh; Deola-Chriakhan Marl at Chirakhan, Sitapuri, Badia, etc., and Upper Coralline Limestone at Chirakhan and Sitapuri.

Hemiaster sub-similis (Fourtau)
(Pl. XII, Figs. 11 and 15)

1887 *Hemiaster similis* (pars) Duncan, non d'Orbigny nec Cotteau: Duncan, p. 92.

1918 *Opisaster sub-similis* Fourtau: Fourtau p. 50, Pl. 2, Fig. 5.

1939 *Hemiaster* (*Proraster*) *sub-similis* (Fourtau): Chiplonkar, p. 243.

Material.—Large number of specimens. Ch 196.

Remarks.—This species was placed by Chiplonkar (1937, pp. 60, 68) under *Hemiaster* (*Proraster*) by removing it from Pomel's *Opisaster*, as

emended by Lambert (Lambert, 1906, p. 102, & Lambert and Thiery, 1909–25, p. 509) to have only two gonopores and restricted to the Tertiary period. But the ethmophractic apical disc and the anterior groove with the frontal sinus very much less developed need removing it from the *Proraster* group also. General physiognomy, nature of the peripetalous fasciole, depressed flexuous petals and well-marked frontal sinus, especially in adult individuals, are some of the characters this species appears to have in common with *Opisaster* which, however, has an ethmolytic apical disc. But for the much shorter posterior petals, it shares particularly in juvenile condition, other characters with *Bolbaster* (Moore, 1966, p. 558, Fig. 442·2). By its general globular aspect of the test, pattern of the peripetalous fasciole, flexuous petals, the posterior pair very much shorter than the anterior pair, grooves carrying the ambulacrals shallow and frontal sinus weakly developed (last two especially in juvenile condition), this species appears close to the one described above, and is probably derived from it by developing deeper grooves a distinct though not deep frontal sinus and a test slightly less elevated.

It may also be mentioned here that the apical disc in the present species though still ethmophractic, has its madreporic plate extended more posteriorly than what is seen in the species described earlier (*i.e.*, *H. holoambitatus*).

It is thus possible that this species probably leads to *Opisaster* which has an ethmolytic apical disc with 4 to 2 gonopores, but is otherwise similar to these two species [*i.e.*, *H. holoambitatus* Chipl. and *H. subsimilis* (Fourtau)] which in fact were placed by Fourtau (1918, pp. 50–51, Pl. 2, Figs. 4–5) in that genus.

Occurrence.—Nodular limestone at Walpur, Guneri, Rampura, Bagh and Mahakal. Deola-Chirakhan Marl at Sitapuri and Chirakhan.

Hemiaster (*Mecaster*) *rarus* sp. nov.
(Pl. XII, Figs. 2 and 6)

Material.—One specimen. *Holotype* Si 238/69.

Dimensions: ..	Length	Breadth	Height	L/B	L/H
Si 238/69 ..	24 mm	21 mm	15 mm	1·1	1·6

Description.—The test is oval in outline having its maximum width between 1/4th and 1/3rd of the length from the anterior side. The summit of the test lies at 3/4ths of the length from the anterior margin. The upper face slopes gently towards the anterior side. The posterior face is almost

vertical and slightly depressed medianly. Periproct is oval and nearly at the top of the posterior face.

The anterior odd ambulacrum is situated in a broad groove cutting the ambitus with a shallow broad frontal sinus and reaches upto the peristome. The ambulacral pores are sub-circular.

The anterior paired petals are slightly longer than the posterior ones and are situated in deep, narrow grooves, the pore pairs in them being 42–44 and 32–34 respectively. Poriferous zones are of the same width as the interporiferous zones. The slit-like pores of the outer columns are in straight lines, while those of the inner columns are very feebly chevron-like.

Peripetalous fasciole has an even course and runs just outside the tips of the petals. The peristome is situated between 1/4th and 1/3rd length from the anterior.

Remarks.—Present species for similarity of its outline can be compared with *H. batnensis* Coq. (Coquand, 1862, p. 248, Pl. 26, Figs. 6–8), from Mornasian (Cenomanian) of Constantine, and *H. auressensis* Peron and Gauthier (Cotteau, Peron and Gauthier, 1879, p. 66, Pl. 1, Figs. 4–7) and *H. fourneli* (Deshayes) (Cotteau. Peron and Gauthier, 1879, p. 58, Pl. 2, Figs. 1-8) both from Senonian of Algeria; but they all have their summit a little more sub-central, and posterior ambulacral petals longer than those in our species.

H. batnensis Coq. shows these differences to the least extent and is nearest to our species.

Occurrence: Deola-Chirakhan Marl at Sitapuri.

Hemiaster (*Mecaster*) *chirakhanensis* Chiplonkar
(Pl. XII, Figs. 3 and 7)

1937 *Hemiaster* cf. *thomasi* Peron and Gauthier: Chiplonkar, p. 65, Pl. 6, Fig. 2.

1939 *Hemiaster* (*Mecaster*) *Chirakhanensis* Chipl.: Chiplonkar, p. 240, Pl. 25, Fig. 4.

Material.—Large number of specimens, *Neotype* Si 232/69.

Remarks.—The specimens in our collection by their salient features, *e.g.*, sub-trigonal test, greatest width at 1/4th of the length from the front, steeply truncated posterior face and ambulacral plates having two horizontal rows of minute granules along their suture, agree fully with *H.* (*mecaster*) *chirakhanensis* as described and figured by Chiplonkar.

Occurrence.—Deola-Chirakhan Marl and Upper Coralline Limestone at Bowarla, Chirakhan, Sitapuri, etc.

Hemiaster (*Mecaster*) *fourtaui* Chiplonkar
(Pl. XII, Figs. 10 and 14.)

1887 *Hemiaster cenomanensis*: Duncan non Cotteau; Duncan, p. 91.

1918 *Hemiaster oldhami* Fourtau non Noetling: Fourtau, p. 46, Pl. 2, Figs. 2–3.

1937 *Hemiaster fourtaui* Chipl.; Chiplonkar, p. 64.

Material.—Large number of specimens. *Neotype* No. Bw 58/69.

Remarks.—With subpetagonal to oval outline; width very nearly equal to the length; the summit at 3/5ths of the length from the anterior; anterior paired petals with 42–44 pore pairs and posterior petals with 30–32 pore pairs present specimens agree with *H. fourtaui* Chipl., described by Chiplonkar from the Bagh Beds.

Occurrence.—Nodular Limestone at Rampura; Deola Chirakhan Marl at Chirakhan, Sitapuri, Bowarla, etc.; Lower and Upper Coralline Limestone at Chirakhan, Sitapuri, Bowarla, Badia, etc.

Hemiaster (*Mecaster*) *heberti* (Coquand)
(Pl. XII, Figs. 4, 8 and 19)

1878 *Hemiaster hebertii* (Coq.): Cotteau, Peron and Gauthier, p. 129, Pl. 7, Figs. 1–3.

1914 *Hemiaster hebertii* (Coq.): Fourtau, p. 75, Pl. 7, Figs. 1–2.

1939 *Hemiaster hebertii* (Coq.): Chiplonkar, p. 242 and the synonymy given by him.

Material.—Large number of specimens. Si 279/69.

Remarks.—Specimens from the Bagh Beds by their cordate outline of the test, the length and breadth nearly equal, rather flat upper surface and ambulacral areas in comparatively shallow grooves, agree with *H. heberti* (Coq.) from Cenomanian of Algeria and Egypt.

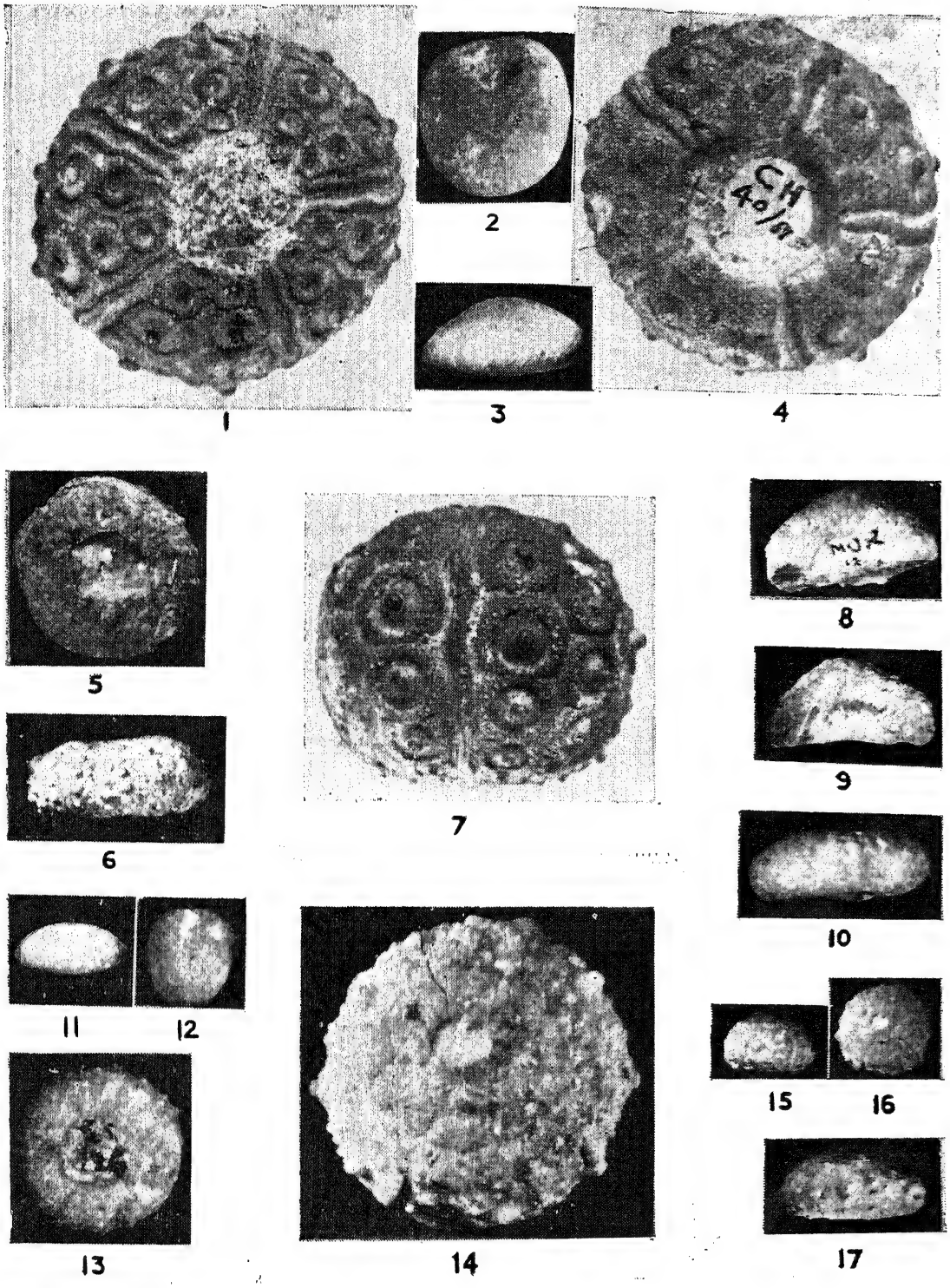
Occurrence.—Deola-Chirakhan Marl at Bowarla, Chirakhan and Sitapuri.

Hemiaster (*Mecaster*) *meslei* Peron and Gauthier
(Pl. XII, Figs. 1 and 5)

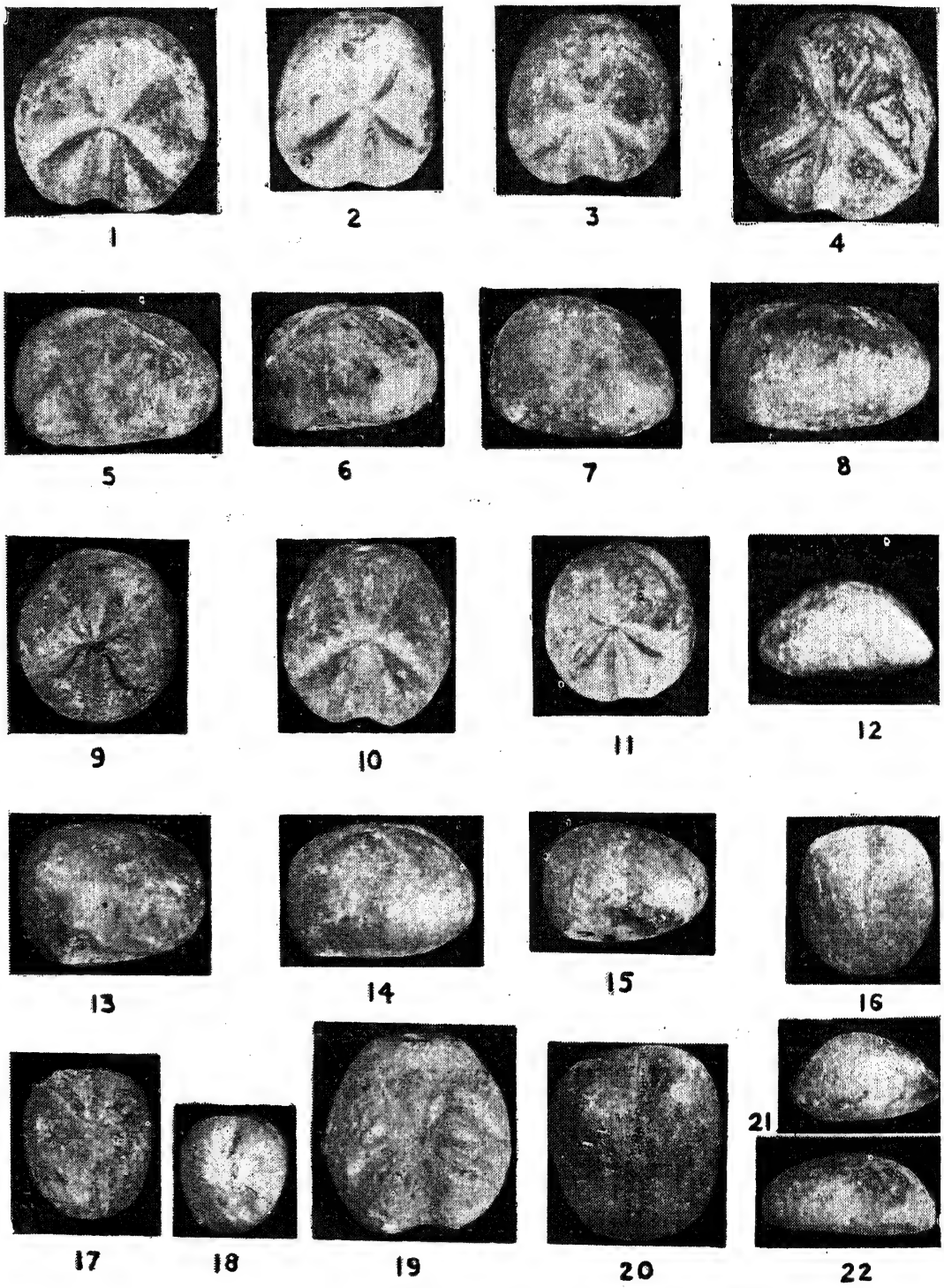
1878 *Hemiaster meslei* Peron and Gauthier: Cottau, Peron and Gauthierl. p. 10, Pl. 2, Figs. 5–8.

1937 *Hemiaster meslei* Peron and Gauthier: Chiplonkar, p. 65.

Material.—Large number of specimens. Bw 57/69.



FIGS. 1–17



FIGS. 1–22

Remarks.—By its sub-circular outline, equal length and breadth, and posterior paired ambulacra being 2/3rds of the anterior pair, present specimens agree with *H.* (*Mecaster*) *meslei* from Cenomanian of Algeria, Tunis and Egypt.

Occurrence.—Deola-Chirakhan Marl and Upper Coralline Limestone at Bowarla, Chirakhan, Sitapuri, Badia and Zirabad.

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Explanation of Plates XI and XII

All the figures are of natural size except otherwise indicated.

Plate XI

Figs. 1, 4 and 7. *Cidaris namadicus* Duncan. Fig. 1. Oral view. Fig. 4. Aboral view. Fig. 7. Lateral view. (Sp. No. Ch 40/69.)

Figs. 2 and 3. *Nucleolites chirakhanensis* (Chipl.). Fig. 2. Aboral view. Fig. 3. Lateral view. (Sp. No. Ch 403.)

Figs. 5 and 6. *Phymosoma mongraensis* sp. nov. Fig. 5. Aboral view. Fig. 6. Lateral view. (Sp. No. Mor. 114/69.)

Figs. 8, 9 and 10. *Polydiadema bosei* sp. nov. Fig. 8. Oral view. Fig. 9. Aboral view. Fig. 10. Lateral view. (Sp. No. Mor. 123/69.)

Figs. 11 and 12. *Nucleolites rajnathi* (Chipl.). Fig. 11. Lateral view. Fig. 12. Aboral view. (Sp. No. Si 312/69.)

Figs. 13 and 17. *Phymosoma namadicum* (Fourt.). Fig. 13. Aboral view. Fig. 17. Lateral view. (Sp. No. Si 126/69.)

Figs. 14, 15 and 16. *Salenia mathuri* Chipl. Fig. 14. Aboral view, showing details of apical disc, × 3·5. Fig. 15. Lateral view. Fig. 16. Aboral view.

Plate XII

Figs. 1 and 5. *Hemiaster* (*Mecaster*) *meslei* Per. and Gauth. Fig. 1. Aboral view. Fig. 5. Lateral view. (Sp. No. Bw 57/69.)

Figs. 2 and 6. *H.* (*Mecaster*) *rarus* sp. nov. Fig. 2. Aboral view. Fig. 6. Lateral view. (Sp. No. Si 238/69).

Figs. 3 and 7. *H.* (*Mecaster*) *chirakhanensis* Chipl. Fig. 3. Aboral view. Fig. 7. Lateral view. (Sp. No. Si 232/69.)

Figs. 4, 8 and 19. *H.* (*Mecaster*) *herberti* (Coq.). Fig. 4. Aboral view. Fig. 8. Lateral view. (Sp. No. Si 279/69). Fig. 19. Aboral view (Sp. No. Ch 195.)

Figs. 9 and 13. *Hemiaster holoambitatus* Chipl. Fig. 9. Aboral view. Fig. 13. Lateral view. (Sp. No. Ch 65.)

Figs. 10 and 14. *H.* (*Mecaster*) *fourtaui* Chipl. Fig. 10. Aboral view. Fig. 14. Lateral view. (Sp. No. Bw 58/69.)

Figs. 11 and 15. *Hemiaster subsimilis* (Fourt.). Fig. 11. Aboral view. Fig. 15. Lateral view. (Sp. No. Ch 196).

FIGS. 16 and 21. *Nucleolites chirakhanensis* (Chipl.). Fig. 16. Aboral view. Fig. 21. Lateral view. (Sp. No. Si 316/69.)

FIGS. 17 and 22. *Nucleolites elongatus* sp. nov. Fig. 17. Aboral view. Fig. 22. Lateral view (Sp. No. 401).

FIGS. 18. *Nucleolites rajnathi* (Chipl.). Aboral view. (Sp. No. Si 311/69.)

FIGS. 20 and 12. *Nucleolites malwaenensis* (Chipl.). Fig. 20. Aboral view. Fig. 12. Lateral view. (Sp. No. 403.)